γ-Jet Studies

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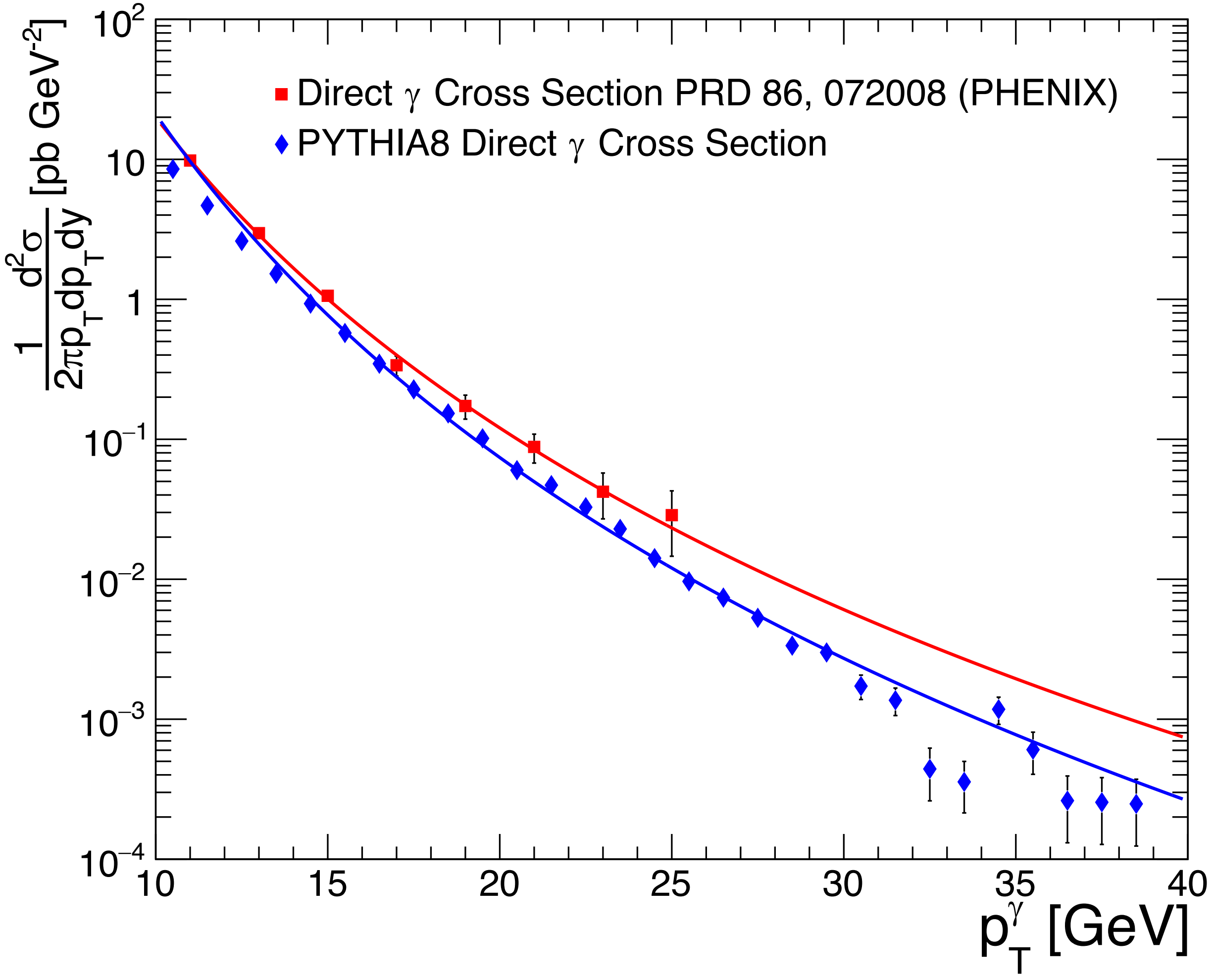
Last Time

- Last presentation March 13, 2017
- Showed estimated yield of γ-jet for sPHENIX
- Suggestion to look at PYTHIA γ-jet cross section to cross check yield estimate from PHENIX direct γ cross section
- Today
  - PYTHIA cross section cross check
  - Some preliminary look at background to γ-jet and what LHC experiments see

Cross Section Cross Check

- Ralf suggested to look at the γ-jet cross section in PYTHIA to compare to the direct γ cross section from PHENIX used to estimate the number of yields
- First, look at apples-to-apples comparison between direct photon cross sections
- PYTHIA underestimates cross section

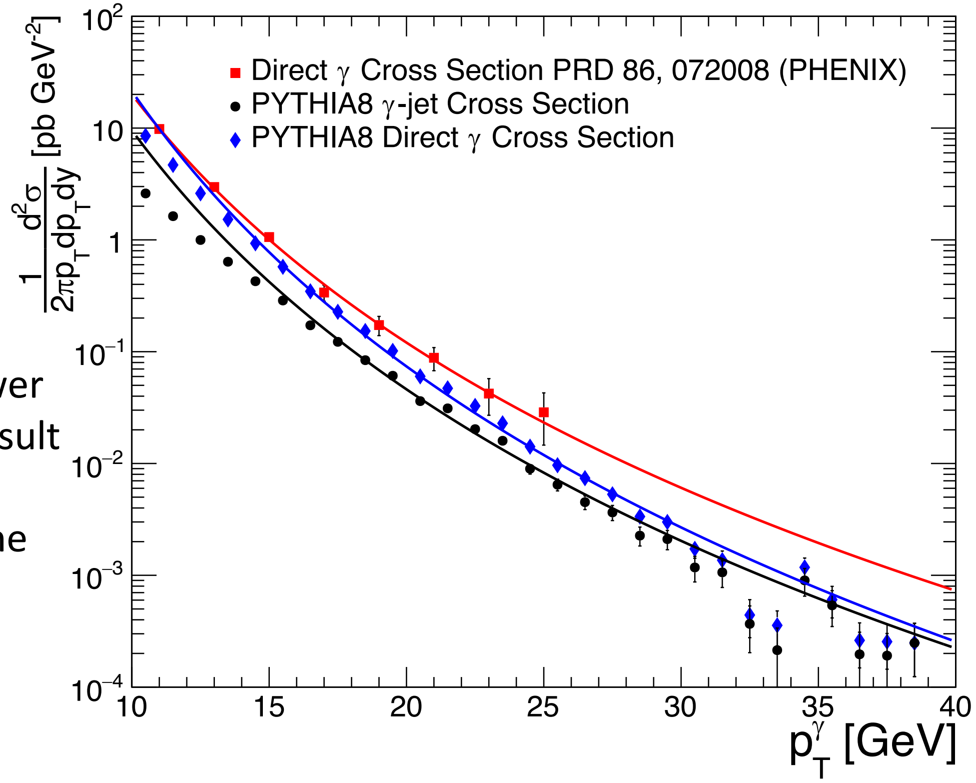


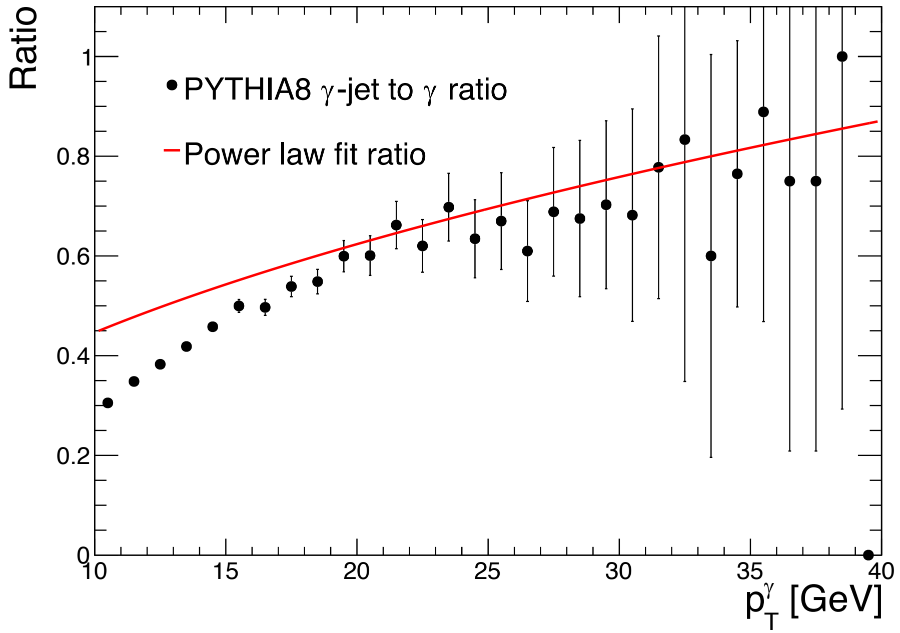
Divergence from power law at small p_T is a result of the phase space constraints used in the PYTHIA simulation

Updated Yield Estimate

- PYTHIA shows that the γ-jet cross section is smaller than the direct γ cross section (makes sense)
- For a yield estimate I will still start from the PHENIX cross section for direct photons since this is actual data
- I will apply the ratio of γ/γ-jet as a "γ-jet efficiency" factor to the yields from last time

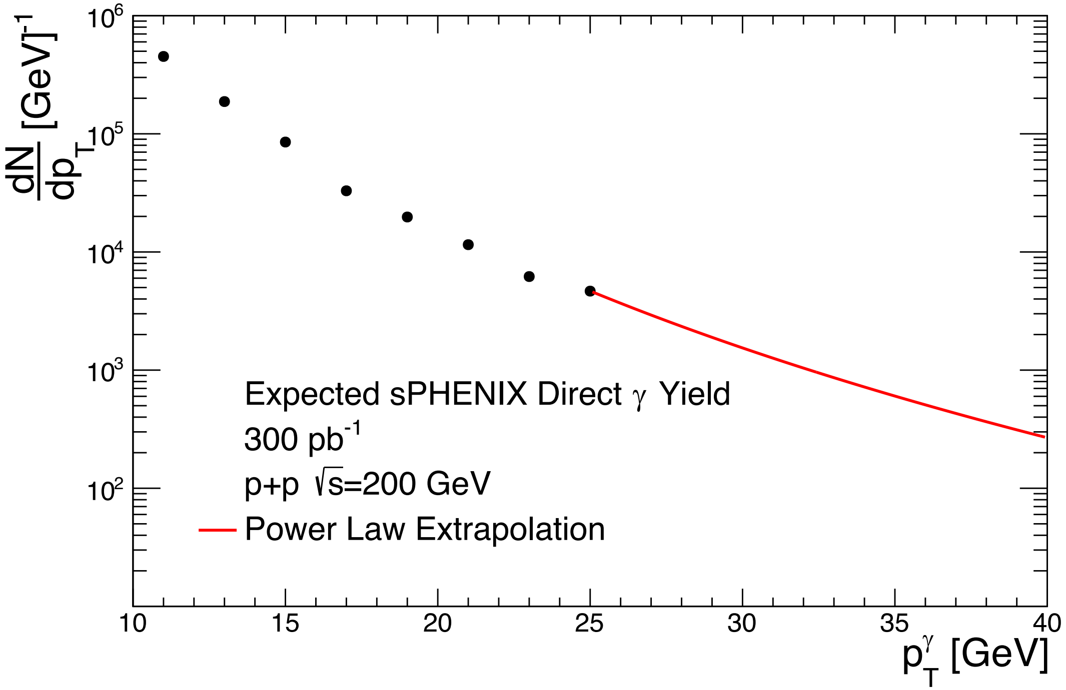
Divergence from power law at small p_T is a result of the phase space constraints used in the PYTHIA simulation

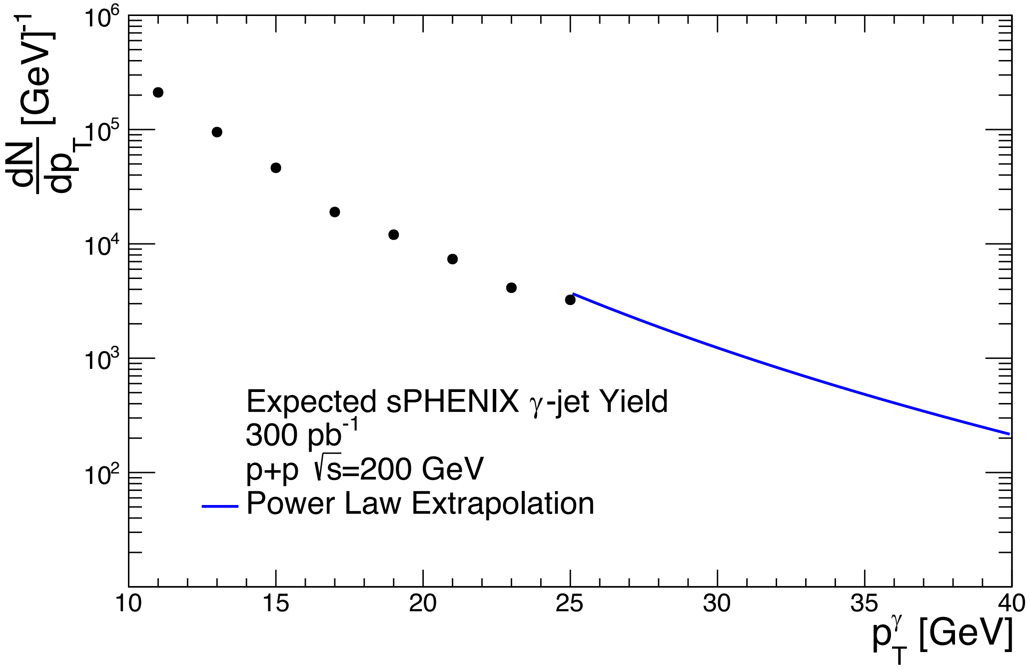




Updated Yield Estimate

- The plot from last time is true as labeled – this is the expected direct γ yield in sPHENIX (~800k direct γ from 10-40 GeV)
- Applying the PYTHIA determined "γ/γ-jet" efficiency gives the following yield for γ-jet
- Amounts to ~400k total γ-jet between 10-40 GeV





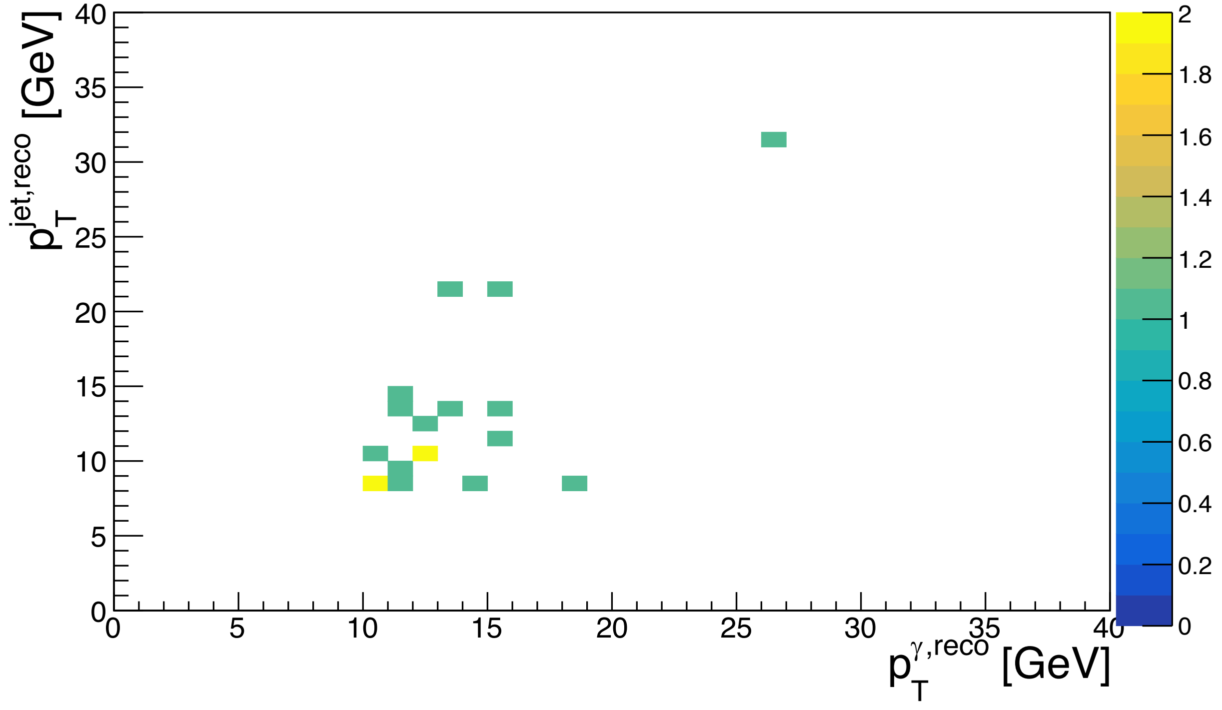
Dijet Studies

Dijet Background

- In real data, the selection of γ-jet is of course much harder due to the ~1000x smaller cross section than dijet events
- What kind of background do dijet events bring about?
- For the kinematics observed here (p_T^{γ}>10 GeV, p_T^{jet}>8 GeV), nearly all of the background will come from large z, highly collimated π^0 decays
- Ran PYTHIA simulation with all hard QCD events and a jet trigger requirement p_T^{jet}>8 GeV within sPHENIX acceptance
- To start out, impose restrictive fiducial cuts:
    - Require photon to be isolated within cone radius of 0.4 (isolation criterion same as other PHENIX criteria)
    - Also require entire isolation cone to fall within sPHENIX acceptance, i.e. only accept isolated photons with $|\eta|<0.6$
    - Processed 146k dijet events

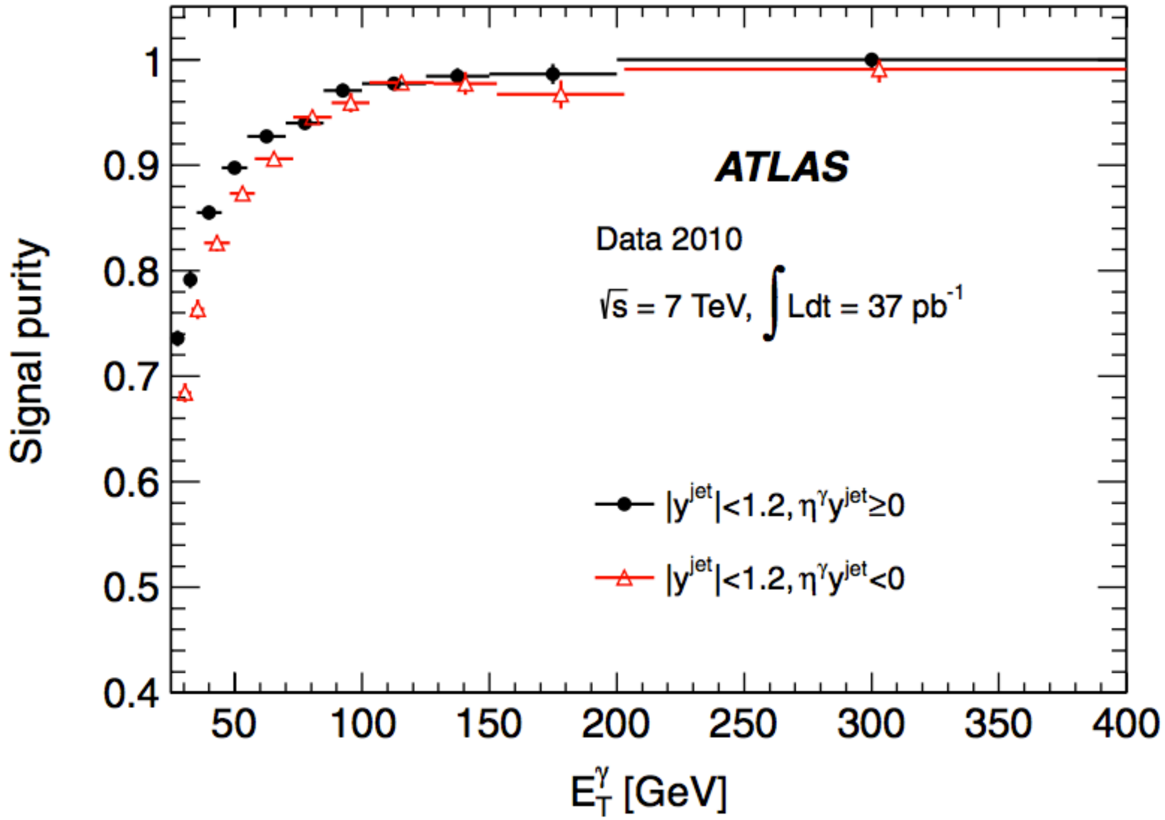
Dijet Background

- In ~150k dijet events, only ~20 pass this restrictive isolation criterion
- This is ~0.02% of the events
- So if we impose strict fiducial cuts, it seems we can be very confident in the high purity of γ-jet in p+p
  - Additional check showed that reducing the isolation cone size to R=0.3 raised this percentage negligibly to 0.03%



What do others do?

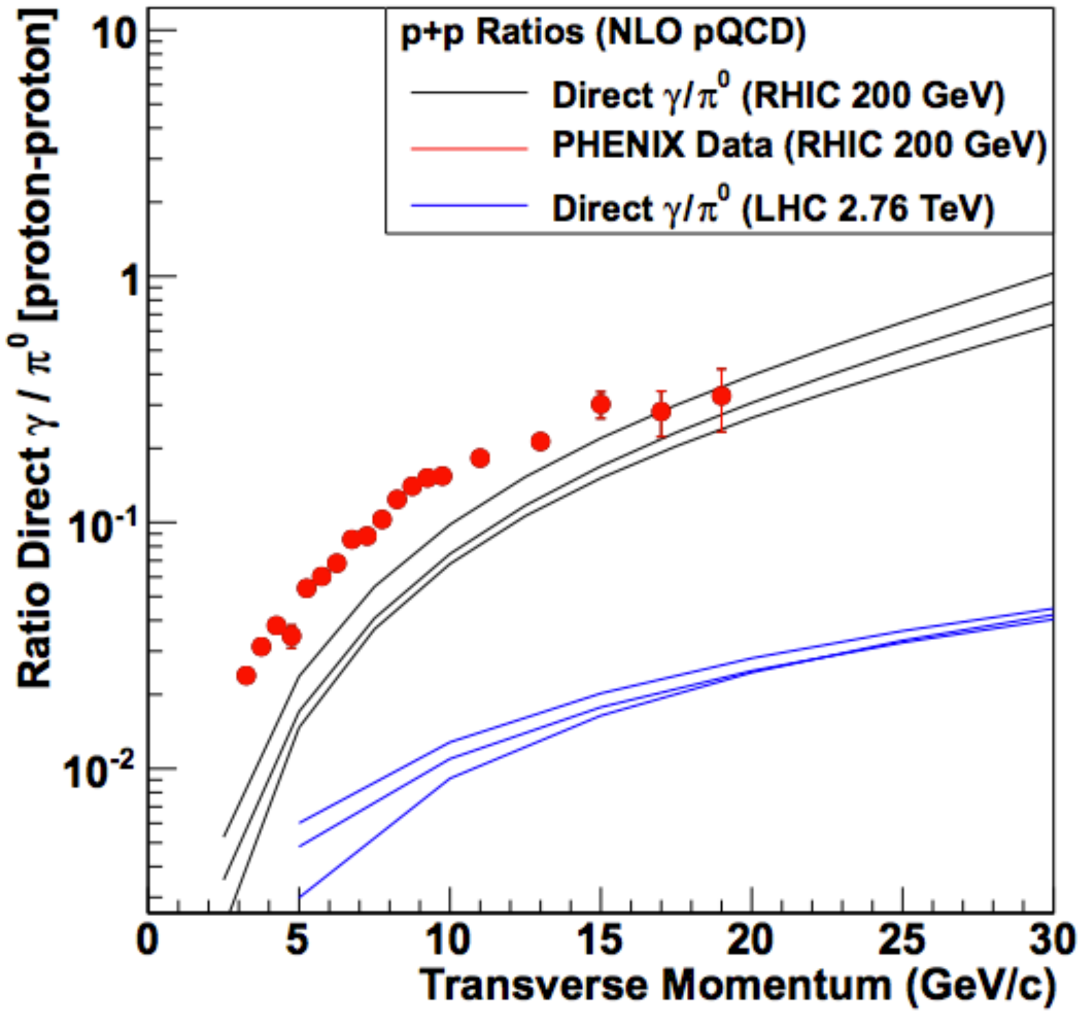
- Using ATLAS Phys. Rev. D 85, 092014 (2012) as an example (isolated photon+jets)
  - Barrel fiducial cut on γ: $|\eta|<1.37$ (full calorimeter+tracking regime is $|\eta|<2.37$)
  - E_T^{iso} of photon required to be <3 GeV
    - This is a stronger cut than I require as it is *at most* 10% of the photon's energy
  - Perform 2D background subtraction which is standard amongst all isolated photon observables at LHC
    - We would have to do something similar; it shouldn't be so difficult though as the method is well documented and used by ATLAS in all isolated photon+X measurements



- Reach signal purity of 97% by $x_T=2E_T/\text{sqrt}(s)=2.*100/7000\approx 0.03$
- For RHIC energies this x_T corresponds to $E_T\approx 3$ GeV so we are well above this in the kinematic region $p_T^{\gamma}>10$ GeV
- i.e. we should have very high signal purity at RHIC

Dijet Background

- The very high signal purity fraction in the ATLAS measurement at higher x_T means at RHIC we should have quite high signal purity fraction at our even higher x_T
- We will still have to do some background fraction estimation of course, but based on this it looks like the background fraction will actually be smaller than at LHC
- This general conclusion matches NLO calculations in e.g. the sPHENIX proposal



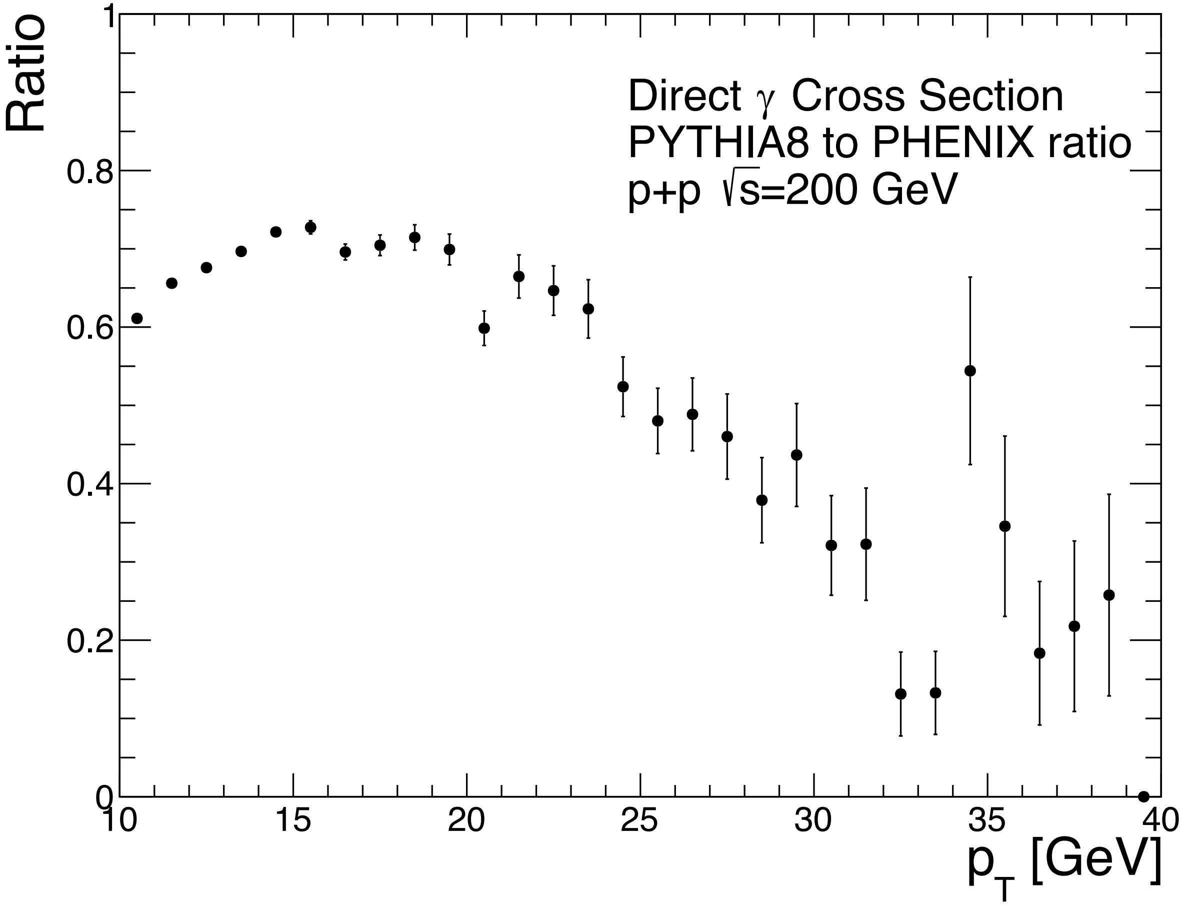
Conclusions

- Previous yield estimate based on direct photon cross section is accurate for p+p->γ+X
- Updated yield estimate for p+p->γ+jet+X with PYTHIA γ/γ-jet efficiency
- Dijet background appears to be small at the higher x_T probed at RHIC energies when compared to LHC
  - Includes strong fiducial cuts right now, which we will probably use anyway at sPHENIX since the acceptance is so much better than PHENIX
- To-Do
  - Start working with full production output of ~800k γ/~400k γ-jet events to make some statistical projections on physics observables

Back up

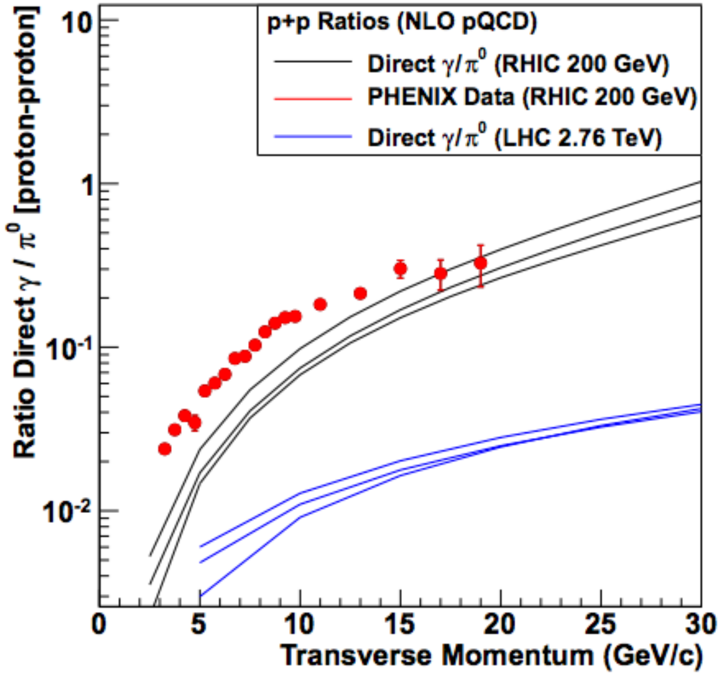
Ratio

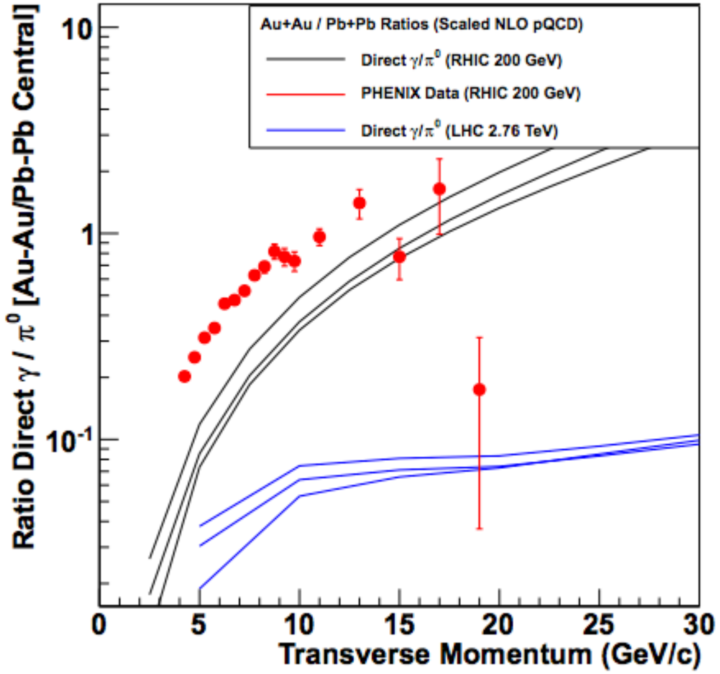
- Ratio of PYTHIA cross section to PHENIX power law fit
- Above 25 GeV the ratio is perhaps not as reliable since there is no PHENIX data there to constrain the fit
- PYTHIA underestimates the cross section by about 60-70%



Cross check Yield Estimate

- JS topical group expects ~10k direct photons from 30-40 GeV in Au+Au collisions
- Au+Au γ cross section is ~10x larger than in p+p
- Therefore we should expect ~1k from 30-40 GeV in p+p
- This matches the new estimate after the γ/γ-jet efficiency application on previous page





Production from Chris

- I had Chris produce G4 hits files for 1.3 million qg->qγ and qqbar->gγ events
- After the efficiency from sPHENIX this amounts to ~800k direct photons (expected yield) and ~400k γ-jet (expected yield) in the sPHENIX detector
- Anyone who is interested in direct photon related observables can take a look with their own analysis code (or mine, in github)
- G4 hits files are located in /sphenix/sim/sim01/production/photonjet/pthat6_eta1/
- PYTHIA events require photon p_T>10 GeV in $|\eta|<1$